A HYBRID CAN-TCP/IP DATA-ACQUISITION NETWORK FOR RESEARCH ON STINGLESS BEES.

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The study of bees, in particular stingless bees, has attracted the attention of several researchers worldwide. However, they have reported several difficulties in collecting and organizing experimental data.

A previous work, called WebBee, presented a system for collecting and storing data, but the prototype of the data-acquisition subsystem was not meant to be reproduced and used in a great number of colonies. This paper presents a new architecture for that data-acquisition subsystem, based on two open and widely utilized protocols: CAN (Controller Area Network) and TCP/IP.

The instrumentation level is based on the CAN protocol. This choice allows the implementation of a low cost and high performance network of intelligent instruments. At the supervisory level, there is a module with CAN and Ethernet interfaces embedded. It uses the TCP/IP stack and an embedded web server. The choice of TCP/IP allows an easy integration with database systems and it is foreseen an integration with WebBee.

The technology proposed permits the acquisition of more data and with better quality than before. It allows gradually scaling up the data-acquisition system, adding up new technologies if necessary or desired, until it becomes a geographically distributed laboratory.

Keywords: CAN, TCP/IP, embedded webserver, intelligent instruments, agricultural automation, automation, microcontrollers, eZ80, stingless bees.

1. The research on stingless bees.

The study of bees, in particular stingless bees, has attracted the attention of several researchers worldwide and especially in Brazil, where there are many native species. Their importance lays in their activity as pollinators of agricultural crops and plants of environmental interest [2]. Some of them can be used also for honey production and there is a growing interest on using them for pollination of high value crops inside greenhouses.

Among the studies of stingless bees, there are the taxonomy ones, that aim at identification of different species and their geographic distribution. This kind of information is essential for the existence of environmental preservation and recovery programs [1].

There are also studies about flight activity, which try to correlate the effect of climate on the bees' external activity, such as searching for nectar and pollen [3] [5] [6]. Those correlations will suggest whether a species might exist in a certain geographic region or whether it could be used as pollinator of a certain crop [7] [6].

To carry out the studies and experiments about the behaviour of stingless bees considering climatic variability, it is necessary to have the resources to measure such variables as air temperature, air humidity, luminosity, among others, and to store and organize them. Some researchers have been facing problems to collect this kind of data with the necessary accuracy and reliability [1] [2].

A previous work, called WebBee [1] [2], presented an information system to support the research on stingless bees. It provides tools to organise publications and documentation, a database for taxonomy studies and a way to collect and store information such as temperature, humidity and bee activity measurements from laboratory equipment. The system is based on a data acquisition board, a database and a web interface. The prototype of the data-acquisition subsystem, however, was not meant to be reproduced and used in a great number of colonies.

This work intends to present an improved solution for a data acquisition system, with characteristics of modularity, expansibility and compliance with open standards.

2. The data acquisition network.

A system with a data acquisition board is a centralized system. The analogue and digital sensors are connected to the data acquisition board located inside a microcomputer, which is the responsible for reading and processing the data. It can be a good solution for a experimental system with a small or fixed number of sensors, but its modularity and expansibility is limited by the computer available slots; by the maximum distance allowed between sensors and the central board. Its price per colony can be high since the system involves one or multiple PCs and data acquisition boards.

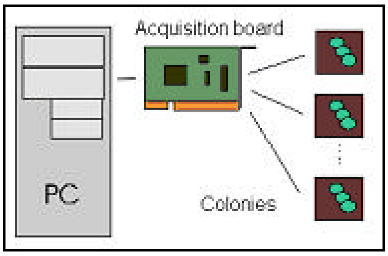

Figure 1 – A centralized acquisiton system.

The solution presented in this paper is based on a network of intelligent instruments. An intelligent instrument is usually a microprocessor-based equipment with data processing capability, which is able to control a small number of sensors, digitalizing, processing and even storing their information locally.

With a network of intelligent instruments it is possible to transmit more and better information, than with a centralized architecture that uses analog sensors. There is no need of a central controller; the instruments can communicate among themselves, making up a decentralized system. Another advantage is that cabling, installation and troubleshooting costs are generally reduced with a network. This kind of system is also more reliable, expansible and configurable than a centralized one [15] [16].

The network proposed here is subdivided in two levels: instrumentation and supervisory. The instrumentation level is constituted by the intelligent instruments, one per bee colony, and is responsible for collecting their data. The supervisory level is responsible for gathering the data from the various instruments, and is also the interface with users and with other systems.

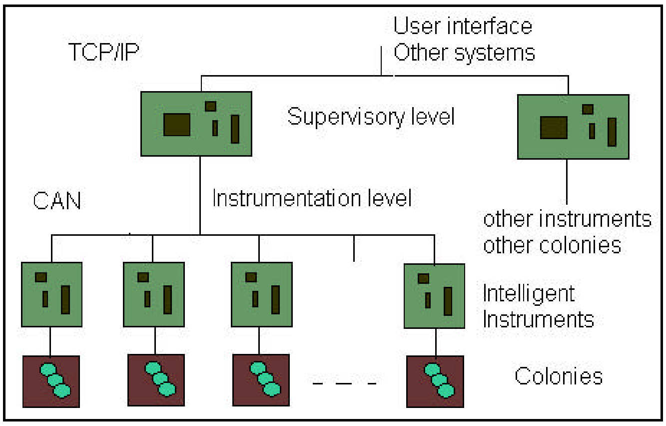

Figure 2: The data acquisition network.

The use of open standards for as many parts of the system as possible makes it easier to expand and improve, because it is possible to choose parts as sensors and controllers from different manufacturers. It also improves interoperability with other systems.

3. The instrumentation level.

At the instrumentation level the network is based on the CAN protocol. CAN, or Controller Area Network, is an open network standard that was first used in automotive industry, but nowadays is accepted and used in a wide range of areas, such as industrial automation, building automation, agricultural machinery, among others [11] [13] [14].

A CAN based network can work with real time applications and offers low cost and high reliability. The standard defines the physical and data link layers of ISO/OSI reference model. The data transmission is serial, using differential signals. Messages are sent by broadcast and there are mechanisms of priority and error detection. The bandwidth can be as high as 1Mbit/s [3] [4].

Problems with modules on the network, or even on cabling, do not prevent other modules from continuing to work. It is also easy to add new modules to a working network. A wide range of manufacturers such as Intel, Philips, NEC, Siemens, Motorola, among others, produce CAN controllers.

The intelligent instruments are based on a 8051 family microcontroller: the Philips P87C591. This chip has an integrated CAN controller and an integrated A/D converter, among other interesting characteristics. This choice was based on its availability and on the wide range of free and commercial high quality tools available for the 8051 family, such as compilers, assemblers and simulators. There are many similar microcontrollers of this family available from other manufacturers, which could be used with little modifications to the hardware and software architectures. It is possible, however, to construct compatible intelligent instruments with other technologies, as PIC chips, for example.

Each instrument has analogue and digital inputs, and is able to measure variables as temperature, humidity, activity of bees, luminosity, among others, since the suitable sensor has been provided.

4. The supervisory level.

The supervisory level is based on the Ethernet interface and TCP/IP protocol. This protocol is widely used in office automation and on the Internet. Its large use on PCs has lowered the prices of its components, and it is being applied to many new areas, as industrial automation, embedded applications, among others [10]. Today, it is possible to implement Ethernet and TCP/IP on small boards, driven by microcontrollers and, although the protocol use at instrumentation level has yet some problems such as relatively high costs (as compared with CAN, for example) and real time constraints, its acceptance in automation field is growing every day.

At the supervisory level the board uses a Zilog microprocessor, called eZ80. The Zilog development kit provides a free TCP/IP library. It is possible and easy to construct a web server based on this processor and the library. A CAN controller was added to the board to provide communication with the lower level. Through the interface provided by the web server, the users and other systems, such as Webbee, can access the data from the instrumentation level [8] [9].

Another advantage of this choice is the facility of integrating several subnets, even geographically separated, using the Internet, what would allow the construction of a distributed data-acquisition system, or a virtual laboratory, making it possible for researchers from distinct countries to work together. The use of TCP/IP at this level permits also the expansion of the network by making use of technologies other than CAN for the instrumentation level.

5. Future enhancements.

The instrumentation level of the system described in this paper, based on a CAN network, is very suitable for applications inside a laboratory, but it is not adequate for use in an open environment. An instrumentation level based on wireless technology, such as Bluetooth, for example, would be easily integrated with the whole system and would solve the problem.

The web server based interface could be implemented also as Web Services. A Web Service is a kind of Remote Procedure Call, based in HTTP and XML protocols, that is the heart of Microsoft .NET technology. It would also facilitate the integration of the system with other systems.

It could be created an interface IEEE 1451 to the instrumentation level. This standard defines a network-independent interface for sensors. With this interface it would be even easier the integration of commercial sensors to the system [12].

6. Conclusion.

The network based system allows the acquisition of more data, and of a better quality than before. It also provides a cheaper solution than a centralized architecture, that can be gradually scaled up, adding new technologies if necessary or desired.

The use of CAN protocol in the agricultural automation field is growing. In part it is because of ISO 11783 standard and its application to agricultural machinery. But CAN is also very suitable as a fieldbus to be used outside vehicular or machinery fields, in applications such as this one.

The use of TCP/IP protocol as a feldbus is also growing. As the prices are lowering and problems with real time performance are being controlled, its use in automation, even at instrumentation level, will be more common.

The proposed architecture can be used in other applications, than bee study. In the agricultural automation field it could be used for controlling or monitoring greenhouses. It also could be used in other fields, such as building automation, for example.

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